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THE MEANING OF THE CRYSTAL[1]

By Sir WILLIAM HENRY BRAGG

DIRECTOR OF THE ROYAL INSTITUTION OF GREAT BRITAIN

IN the time which is allotted to me I should like to explain, if my audience will allow, the scope of the work in which, with my son and others, I have been recently engaged. I must first beg to remind you of certain facts. The elements of construction of the universe are the atoms, of ninety-two different kinds. The first constructive step is the assembling of the atoms into molecules. A molecule is a company of atoms in an association, which has some permanence great or small. The number of kinds of molecules is enormous. The water molecules consist of two atoms of hydrogen and one of oxygen. The molecule of ordinary salt contains one atom of chlorine and one of sodium; the molecule of an organic substance is generally more complicated, as, for example, that of naphthalene, which contains ten atoms of carbon and eight of hydrogen. If the atoms are likened to the letters of the alphabet, the molecules must be compared to words.

The next step in nature's architecture is the linking of molecules to form solid substances, such as the subjects which we see around us and ourselves. The properties of all substances depend upon the way the molecules are put together, just as a house, or its interior, has a character and a usefulness, which depend upon its design, or just as the meaning of a sentence depends on the words it contains and on the way they are arranged.

This second step is not always made: the hindrance to its accomplishment is heat. Heat is a mode of motion. When, for example, the molecules of water are set in very rapid motion by imparting sufficient heat to them, the forces that would make them combine are overcome; the molecules exist as independent individuals and we have water vapor or steam. With less heat and less motion the molecules are always in part-

[1] Medal Day address, delivered at the Franklin Institute, Philadelphia, Pa., on May 21.

nership, but always changing partners, and we have water. Still less heat, and the molecules become permanently attached to each other in unchanging positions, and thus ice is formed. Some molecules feel heat more than others, so that at ordinary temperatures some substances are solid, some liquid, and some are gases.

It is the great aim of scientific research to connect the properties of a substance with the design of its construction. Gases have the simplest design, and the laws of gases are fairly well understood. Liquids come next, and we know something of their laws also. In particular we have learned much of what happens when liquids of different kinds are mixed together; we have watched when molecules pull each other to pieces and make molecules of new patterns out of the old. This is the province of science which we call chemistry. The enormous advances in pure and applied science, for which chemistry is responsible, show how great are the results of research even in this limited field.

But when we come to solids we have to admit that we know very little indeed of the way in which their properties depend on their composition. The fact is that their properties depend on the arrangement of the molecules; these now have definite positions, and the pattern of the arrangement is all important. There was very little of this in liquids and none at all in gases. To make headway we must therefore learn the laws of arrangement. Until recently this has not been possible, and we have been unable to enter a field of research which may well turn out to be the richest of all fields. But the X-rays have now opened the door for us; let me briefly explain how.

I must first say a few words about the capacities of our eyes. It is a strange fact that the eyes of men can see only a minute fraction of the things and the happenings that surround them. The light which brings us our knowledge—daylight, artificial light or lamplight—is narrowly limited in quality, and on that account tells us only a small part of the whole tale. We are accustomed to recognize differences in quality. We speak of red, green, blue and indeed of an infinite variety of shades. The student of physics estimates their differences by reference to the standard of wave-lengths, the waves referred to having their being in a hypothetical medium called the ether. He is not quite sure, in these days, of the amount of reality which should be assigned to these waves, but that is of far less importance than it sounds. The ether and its wave-length furnish for us a most useful language in which to express our thought and measurement. It then appears that the length of the ether waves may lie anywhere between very wide limits. In vision we use a minute section of that range. If we had never found any other means of detecting ether waves except our eyes, we might never have known the limits to our knowledge. But now, as I may remind you, we use very long invisible waves for transmission by radio, and, quite frequently, short invisible rays for the purposes of photography.

Now the quality or wave-length of the light determines what we can see by its means. Small details can be made out by short waves, and become less distinct if the light is of longer wave-length. Even within the narrow range of vision this difference can be observed. In certain microscopes used by biologists only light of extremely small wave-length is employed, the smallest that can be brought to bear upon the photographic plate, or the human retina, and in this way the power of the microscope is extended. On the other hand, it is curious to observe what a difficulty there is in picking up details in a red light, although the wave-length is only twice that of the shortest visible blue.

This strange limitation surely prompts our inquiry as to the reason, if one can be given. It is a fact that waves shorter than the visible cannot penetrate the miles of the atmosphere, so that even if our eyes could see them they would have no use for their powers. If our eyes responded to waves much longer than the normal we should certainly miss much detail that we value. Again it is a fact, of an entirely different bearing, that the perception of light depends on a curious process in which electrons are shifted out of their usual positions in the atoms of the retina. Now the shifting cannot be accomplished if the wave-length of the light is more than about a thousand times longer than the diameter of the atom. As atoms of all sorts have sizes which do not differ widely among themselves, a certain limit is set to the light which the eye, as constituted, can detect. The waves must not exceed a certain length. Since the eyes of all creatures are made and act in much the same way, that which is light to one is light to all. Sir John Lubbock thought that ants could see blue light better than red, and I have seen it stated that certain insects do not appreciate light that has come through yellow glass. Whether these are actual facts or not, it is certain that the range of vision is very small. I do not know that any of these considerations answer the question, why? Mathematicians tell us that a ray of light, the emblem of directness, in continuing its way through space will in time return to where it began, and if we seek to distinguish between cause and effect, we are apt, proceeding step by step, to be in much the same case and to find that the last effect is also the first cause.

The consequence of the limitation is a corresponding restriction of the visible world. We are normally unconscious of all but a fraction of our surroundings.

We have tried to extend our powers. We have first made use of the simple lens, then of the microscope, trying by these means to give to our eyes the more extended use of the light waves that can be seen. But to this effort there is a limit. When the optician has done his wonderful best, and when the shortest light waves are used, there is necessarily a halt; and at one time it seemed that the halt must be a permanent stop. But what new worlds, or rather new comprehensions of the old world, have been opened up by these means alone! We are so accustomed now to the new vision that we have forgotten how strange it must have been to the early users of its powers. When Hooke wrote his "Micrographia" in the middle of the seventeenth century he was in a mood of amazement at what the newly invented microscope told him. Section after section of this fascinating book describes the wonderful and hitherto invisible details of common objects—a hair, a piece of silk, a needle point and so forth. No doubt there were those who thought that these incursions into a new world of knowledge were unjustifiable, and what the eye could not see naturally was not worth seeing, and was not intended to be seen. We have learned that these minute things and happenings affect deeply and immediately our health and happiness and our ability to use the resources of nature. And every improvement in the use of ordinary light by the microscope has added to our realization of the infinite and the unity of nature.

But as I have said, where we have made use of ordinary light, we come to a dead stop in this direction. It is here that X-rays, being what they are, furnish us unexpectedly and magnificently with a new range of vision. Consisting of ether waves, in the same sense that light so consists, but being some ten thousand times shorter, they can take note of details which are far finer than light can show us. It is very important to realize that minuteness does not mean insignificance or want of relation to ourselves. The world which they can portray is as full of richness and variety, movement and interest as that which we see normally. It is true that our eyes see none of it, and so it is not associated with the ideas of beauty in form and colors. We cannot thoughtlessly take pleasure in it, as we may in the other. We must grasp what the X-rays tell us by means of delicate and complicated scientific methods, and our admiration and interest are of the mind only.

What sort of things do we now perceive? We see, if I may use the word in a broad sense, that arrangement of atoms and molecules in the solid body, of which we have been so eager to obtain knowledge. We stand in front of nature's architecture and examine her use of the elements in her construction. And here I must speak of a very important matter. We should still be unsuccessful did we not avail ourselves of one of nature's most remarkable characteristics, one which we have not indeed fully appreciated until now. It is her extraordinary tendency to regularity and order. If it were not for this uniformity, even the new rays could not help us. The effect of a single atom upon X-rays is far too small to detect. The effect is there, as it would not be with visible light, but it is insufficient in quality. But nature arranges her atoms in regular order in millions of millions, and the combined effect is big enough to affect our instruments. It is just as when the wind turns over all the leaves of the poplar tree at the same moment and the whole tree appears silvery gray, and so we learn what we could not have observed from the behavior of a single leaf. A more exact analogy is found in certain colorations of nature, in the hues of butterflies, for example, where a regular assemblage of fine scales makes for color, though each scale is too minute to be visible.

We see, for example, the atoms of carbon in the diamond and their perfect alignment according to a simple plan which gives every atom four other atoms as neighbors equally and regularly spaced about the first. We begin to understand how the design gives the diamond its unique hardness. We see the carbon atoms rearranging themselves according to a new plan to make the soft and slippery graphite. We see the atoms of oxygen, which far exceed all others in number, drawn up in regular order like a pile of shot to form the structure of most of the earth, and held together by atoms of silicon, magnesium, aluminum and so forth. The beautiful forms of the crystals of snow and ice are observed to be derived from the underlying and particular arrangement of the oxygen and hydrogen atoms. We begin to understand the details of construction of those long chains of certain atoms which are of such tremendous importance in the construction of living organisms. It is not to be forgotten that chemical investigation has long made us aware of their existence, but now we see, I think it is fair to say, what hitherto we have only inferred. We get a first rough idea of the actual forms of those curious hexagonal rings of carbon (the benzene ring) which are also of first importance to living things, and in other structures are the basis of dyes and many other great classes of compounds. It is indeed the whole range of nature's first compiling of atoms and molecules to form ourselves and the things about us that now opens to our view. Our untrained eyes do not yet interpret all, even a small fraction of what they see. But as results accumulate and workers grow in number and power, so at the same time our interpretation becomes more accurate and effective. There is infinite opportunity for research, first of all in

description of what the X-ray reveals, just as Hooke disclosed what the microscope told him, and then the greater and even wider enterprise of connecting the structure of bodies with the properties which they possess. You will understand the fascination of this new field of research.

A MOMENTOUS HOUR AT PANAMA[1]

By Dr. JOHN FRANK STEVENS

FORMER CHIEF ENGINEER, THE PANAMA CANAL

THERE has been published from time to time such a mass of information about the Panama Canal, a project which aroused much controversy a quarter of a century ago, that any reference to it after the lapse of years may seem to be quite superfluous; but as is often the case in human affairs, history does not always record events which have had a profound influence for good or evil upon the solution of the problems involved. The history of the planning and construction of the Panama Canal is no exception to such general rule.

The condition of affairs on the isthmus during a part of the year 1905 can truly be described as desperate; by many well-wishers even it was regarded as hopeless. When the speaker arrived there in July of that year, he found not even the skeleton of a general organization. Supreme authority was vested in no one. The Sanitary Department was the only one having the semblance of a proper organization, and it was doing a limited amount of work under what would probably have proved a fatal handicap had it continued. The usual tropical diseases were prevalent, and that scourge of the white race, yellow fever, was taking its deadly toll daily. While the situation was in some degree psychologic, the danger was great, enough so that unless the disease was promptly checked and thereafter held under control, the success of the great enterprise would be jeopardized.

The tragic story of the French attempt to build a canal there was in many mouths, and predictions were freely made that the history of the Americans on the isthmus would be a repetition of the De Lesseps failure. Under the then existing conditions it would not have been possible to hold the small force of clerical and skilled white labor which had been collected, much less to induce thousands of other whites to enter the service. Especially so in view of the pessimistic attitude which some of the American press had taken, and the exaggerated accounts which they were publishing as to living and health conditions on the isthmus, some influential members openly advocating that the whole undertaking should be abandoned as affording no hope of a successful outcome.

At that time few of the general public knew anything of the so-called mosquito theory of the transmission of yellow fever, and they mostly regarded it as purely theoretical. Not so with the medical scientists who had successfully demonstrated it in Cuba, and of those scientists was Colonel William C. Gorgas, of the Medical Corps of the Army, who was the head of the Sanitary Department on the isthmus. He was working intelligently with a small but efficient staff, but with an utter lack of cooperation on the part of his immediate superiors. He was one of the first officials that I met there, and from him I gained my real insight into the famous theory.

Of Colonel (later General) Gorgas, his work and supreme service to mankind, it is unnecessary to speak here. His memory is so deeply cherished and his fame is so secure that no words of mine can add to either. Best of all, he was a kindly, sincere man, the highest type of gentleman, and I am proud to have known him, not only officially, but also as a warm friend.

The then chairman of the Isthmian Canal Commission accompanied me on my first visit to the isthmus, remaining there but five days, as the situation did not appeal to him. At that time Colonel Gorgas was reporting to the governor of the Canal Zone. Neither the governor nor the chairman had the least faith in the efficacy of the mosquito theory—at least they so emphatically advised me at once, and their actions confirmed their words.

Quoting from a brochure of General Gorgas's life and activities, written by the president of the American College of Surgeons:

> Finally, in June, 1905, the governor and chief engineer [my predecessor], members of the executive committee of the commission, united in a recommendation to the Secretary of War that the Chief Sanitary Officer (Colonel Gorgas) and those who believed with him in the mosquito theory should be relieved, and men with more practical views be appointed in their stead. They stated that the sanitary authorities had visionary ideas with regard to the cause of yellow fever, and no practical methods even of carrying them into effect.

The President declared his faith in the theory and directed that every possible support and assistance be

[1] Medal Day address, delivered at the Franklin Institute, Philadelphia, Pa., on May 21.

extended to the sanitary officials. Personally, I have no knowledge except from hearsay of the accuracy of these statements, although I believe them to be true. What I *do* know is that such directions were not carried out either in letter or spirit.

Quoting again from the same authority:

> About this time Mr. John F. Stevens was appointed chief engineer of the commission, and he recommended that the Sanitary Department should be made an independent bureau and report directly to himself. This enabled Colonel Gorgas to make known his needs directly to the highest authority, and there he was accorded loyal support. This, remarks Gorgas, was the high-water mark of sanitary efficiency on the isthmus, and more sanitation was done at this time than during any other period of the construction of the canal.

Incidentally, I may here remark that on my recommendation some time afterward the President appointed Gorgas as a member of the Isthmian Canal Commission.

However, these results were not achieved without a sharp controversy, during which the chief engineer clashed sharply with the chairman and the governor. I had been very deeply impressed by my conferences with Colonel Gorgas as to the probable truth of the mosquito theory, as well as by his personality. I also felt well assured that no canal could be built at Panama until the specter of yellow fever had been laid. There was no other promise of relief in sight than that of Gorgas and the mosquito theory, and there seemed to be but one course to follow.

On the occasion of a trip over the Panama Railroad, accompanied by the chairman and the governor, the sanitary work which was in progress, visible from the train, such as drainage of pools of water, applying oil where drainage was not practicable, fumigation of houses, etc., was pointed out to me in great detail by these officials, accompanied by constant ridicule, not only of Colonel Gorgas but also of the mosquito theory, some of these comments reflecting very severely upon the quality of the colonel's mental equipment.

My attention was repeatedly called to the great waste of money and the utter futility of the whole procedure. It became very apparent that a serious situation existed, and I was in a quandary as to how it could be met, as I well knew that it must be or a total collapse was inevitable. The climax came quickly.

The day before the chairman sailed for the States he advised me that he and the governor had decided that Colonel Gorgas must be gotten rid of (in his precise language, that he would "fire" him), and the mosquito theory, also. Some quick thinking and an important decision were needed on my part, which decision I proclaimed in rather heated language, not to be repeated here. At the close of my harangue, I said that if there seemed to be the least likelihood of approval of his action being given by the President (which I did not believe possible) I should take the matter in person to Washington; and that if Colonel Gorgas were removed I should not come back to the isthmus.

I asked him what he thought the reaction would be from the doubtful ones, and from the already unfriendly press, if it became known that the commission had urged the abandonment of the mosquito theory and the disruption of the Sanitary Department, and stated that, furthermore, if after a hasty visit to the isthmus the new chief engineer had, by his action, indicated his belief that the construction of the canal was impossible, it would mean chaos, whatever attitude the President might take. If it did not kill the project it would certainly delay it, and the end no man could foresee. He left for the States without further comment on the matter. If he urged his views in Washington (which I do not believe he did) I was never advised, and so the matter ended there, as it should.

I was seeking a way to stabilize the situation, for it was no time to be rocking the boat. Opportunity must be given for the Sanitary Department to prove its faith by its works, which I believed it could do.

It was not a question of Colonel Gorgas's business ability, but one of making the isthmus a safe place for white people to live and work in, and that quickly, regardless of whatever cost in mere money might be involved. Beyond doubt those officials were sincere in their opinions, but in my judgment they were wrong.

It was after this occurrence that Colonel Gorgas began to report to me, and from that time forward harmony prevailed. The Sanitary Department was furnished with everything it asked for as fast as it could be provided, and every other activity was made subordinate to its needs. Sanitary success soon became so apparent, coincident with the creation of a general organization, that carping criticism was practically stilled, for the first time since the American occupation of the isthmus. Science had scored a wonderful triumph over a deadly foe to the human race.

Sanitation was fundamental, and the success which the Sanitary Department achieved under Colonel Gorgas made the Panama Canal possible. When the result of its work became manifest, and when the lock type had been adopted, then the successful construction of the canal was as well assured, early in 1906, as it was on that historic opening day in Au-

gust, 1914, when the steamship *Ancon* passed through it from ocean to ocean.

At this distance of time and space the episodes related may seem trivial. Only one who was on the ground, charged with tremendous responsibilities, can comprehend the magnitude of the issues at stake. A rejection of the mosquito theory at that juncture would probably have meant the indefinite postponement of the canal project.

I have said that I did not then deem it possible that President Roosevelt would uphold the elimination of Colonel Gorgas, but an occurrence which took place some years later gave me food for thought. Some time after Mr. Taft had become President, Colonel Roosevelt sent me an invitation to call upon him, which I did at the office of the *Outlook* magazine in New York. After some preliminary talk he told me that friction among officials on the canal had reached such a point that changes would have to be made, and that he thought Colonel Gorgas would have to go. He said that he was well aware that I knew more of Gorgas and his work than any man, and asked if in my opinion he should be kept.

It is needless to repeat what I told him. It was emphatic and to the point, and I closed by saying that if Gorgas were removed it would be a stupid blunder. Colonel Roosevelt pounded the desk in his usual vehement manner and exclaimed, "That settles it; Gorgas stays." Which he did, through what influences one can only conjecture.

I have thought, since that time, that possibly it was just as well that the issue was not raised to a finality in July, 1905. I had reason to know that the President then had great confidence in the chairman, but the status of the chief engineer in that respect had yet to be demonstrated. I did not have faith enough in the result to wish the matter put to a test.

In the year 1914, when Gorgas was Surgeon-General, I received a letter from him, reading in part as follows:

> I have a very clear and grateful recollection of the support and friendship you always gave me on the isthmus. I knew very well that you were the only one of the chief officials who believed in the sanitary work we were doing, and who was not taking active measures to oppose us. The fact is that you are the only one of the higher officials on the isthmus who always supported the Sanitary Department, and I mean this to apply to the whole ten years, both before and after your time, so you can understand that our relations, yours and mine, stand out in my memory of the very trying ten years I spent on the isthmus as a green and pleasant oasis.

Only fragmentary accounts of these episodes have ever been related, and as now that every one of those officials who were directly concerned with them, President, Secretary of War, governor, General Gorgas—every one excepting myself—has passed beyond the sphere of human activities, it seems fitting that while first-hand knowledge of the matters then at issue is yet available, it should become a part of the history of the construction of the canal, for it is not believed that the full significance of these events has ever been appreciated.

SCIENTIFIC EVENTS

TROPICAL DISEASES EXHIBIT AT ANTWERP

According to *The British Medical Journal* the Antwerp Exhibition was opened by the King of the Belgians on April 26. The Tropical Diseases Section, in the British Government Building, was organized under the auspices of the Exhibitions Branch of the Board of Trade, and is under the direction of a committee, of which Major-General Sir Wilfred Beveridge is chairman. The exhibit has been designed to impress upon the general public the importance of knowledge of health matters to those who live under tropical conditions. It also depicts certain dangers and the means by which they may be combated. A complete outline of thirteen important tropical diseases is presented by means of serial illuminated pictures, illustrating the causation, manifestations, treatment and prevention of each disease. Above each series are placed enlarged photographs of work which has been carried out in connection with the disease under consideration. Above these photographs are illuminated statistics showing the beneficial results to the community of such preventive treatment. The organisms responsible for various tropical diseases—protozoa, helminths and bacteria—are demonstrated by color photomicrography in six specially constructed viewing cases. Some of the diseases are dealt with in greater detail in six cases prepared and lent by the Liverpool School of Tropical Medicine, and several excellent wax models of the insect vectors of diseases are shown. Enlarged photographs have been prepared of men who have laid down their lives in the investigation of diseases prevalent in tropical countries; this exhibit indicates the special dangers attaching to research work in yellow fever and typhus. A model of the new London School of Hygiene and Tropical Medicine, taken in conjunction with the Liverpool School exhibit, emphasizes the fact that the importance of education in tropical medicine is recognized. The care

of those suffering from tropical diseases is largely in the hands of the Seamen's Hospital Society, which has prepared an exhibit illustrating the work done by their hospitals. Two small historical exhibits are shown dealing with plague and leprosy in olden times. In the "Manson" exhibit the memory of the "Father of modern tropical medicine" is honored. The Wellcome Museum of Medical Science has been responsible for the detailed organization of the whole exhibit and also for the preparation of all transparencies, photomicrographs and statistics.

THE GERMAN ASSOCIATION OF SCIENTIFIC MEN AND PHYSICIANS

IT is stated in *Nature* that the German Association for Natural Science and Medicine has visited in recent years Innsbruck in the south, Düsseldorf in the west and Hamburg in the north. This year the association will proclaim science and civilization at Königsberg in the far east of Prussia. The invitation circular is not to members of the association alone, but also to all who honor German science, and makes welcome the participation of foreign savants who feel themselves in contact with German research. This ninety-first assembly of the "Gesellschaft Deutscher Naturforscher und Aerzte" takes place on September 7–11, 1930. There will be general addresses, a short program of sectional meetings and numerous joint discussions. Festivities are to be limited in favor of the call of learning. The main topics include protoplasm, bird migration, logic and natural science, the natural system of the elements, agriculture and economics. The medical side will discuss blood pigments and bacteria, and will combine with biologists to discuss inheritance and with physicists to consider the eye. Joint discussions will deal with the cosmic frequency of the elements, the age of the earth, the synthesis of silicates and cosmic radiation. Botanists and agriculturalists will discuss meteorology. Various allied scientific societies are holding their meetings at the same time and place. The program of excursions includes the neighboring sand-dunes, lagoons, bathing-resorts, fresh-water lakes and historic monuments. Longer journeys include Finland for mineralogists before the meeting, and after the meeting Leningrad and Moscow. Königsberg can be reached from Berlin without any further visa, passport or tax; eight times daily by train in 9–10 hours; by fast motor-ship *via* Swinemünde-Zoppot-Pillau, 18 hours at sea; also thrice daily by air in 4–5 hours. The subscription for those attending the meetings, but not regular members, is 25 rm.; applications should be sent to Secretary G.D.N.A., Professor Dr. Rassow, Leipzig C.1, Gustav-Adolfstr. 12, and if possible by mid-May by those wishing to join excursions.

A GOVERNMENT GAME RESERVATION

A SPECIAL correspondent of *The Christian Science Monitor* reports that if proposed legislation now before the House of Representatives is passed, a great game preserve capable of providing food and resting places for more than 200,000 birds at one time and of producing more than 1,000,000 in a year will be added to the national reserves of the United States government.

The Senate has already passed a bill providing for the expenditure of $300,000 for the purchase of the shallow lake which has since 1927 covered a barren area of about 20,000 acres in Barton County, Kansas, known as the Cheyenne Bottoms. Mr. Clifford R. Hope, representative from Kansas, is reported to have said that with the support which the Department of Agriculture has indirectly given to the bill its passage is assured.

Adherents of the measure point out that the Cheyenne Bottoms are situated in the path of the migrations from Alaska to the south. Banding of the birds has shown that those which frequent the Bottoms come from Alaska and many parts of Canada and go as far south as Yucatan. They come in thousands and in great variety.

Immediate action on the measure is necessary as efforts are being made by owners of the land over which the lake now flows to have it drained. They have an investment in the property and feel that some return can be obtained by its use for grazing if it can first be drained. In 1928 they formed a company for this purpose. Opposition of various societies and groups interested in the preservation of wild bird life was strong enough to procure an injunction against the drainage proceedings. But owners can not be permanently restrained from treating their property as they wish. Therefore the federal government is being approached in hope that the entire district may be purchased and formed into a migratory bird reserve.

If obtained for the nation the Cheyenne Bottoms would be cared for under the provisions of the Norbeck-Anthony bill which furnishes appropriations for the work of the Biological Survey.

THE COAL RESEARCH LABORATORY OF THE CARNEGIE INSTITUTE OF TECHNOLOGY

GIFTS amounting to $425,000 to extend over a five-year period for the establishment and maintenance of a coal research laboratory at the Carnegie Institute of Technology have been announced by Dr. Thomas S. Baker, president of the institute.

The Buhl Foundation of Pittsburgh is the largest single donor to the project, contributing $50,000 at

the outset for the equipment of the laboratory and $25,000 a year for five years for a program of pure research. The gift of the Buhl Foundation is made with the stipulation that certain additional amounts shall be secured from other sources. This condition has now been met through the cooperation of six great American firms. These are the United States Steel Corporation, the General Electric Company, the Koppers Company, the New York Edison Company, the Standard Oil Company of New Jersey and the Westinghouse Electric and Manufacturing Company. These six corporations will contribute a total amount of $50,000 a year for five years for the maintenance of the laboratory.

The laboratory will be located on the north side of Engineering Hall of the Carnegie Institute of Technology in a new wing constructed last summer. The plan for the new laboratory will go into effect July 1, 1930. The names of the director and members of the scientific staff will be announced soon.

The laboratory will be a part of the Carnegie Institute of Technology, and will undertake fundamental research in coal and the products which may be obtained from it. Graduate courses will be offered for the training of students in fuel technology in connection with the research laboratory, with the research staff giving instruction.

An advisory board, consisting of prominent men of affairs interested in coal research, will be appointed, to advise as to the general policies to be followed by the laboratory. A technical committee, including representatives of the companies that have contributed towards the support of the project, has been appointed to assist in selecting the staff and arranging the research program. This committee is composed of Dr. John Johnston, U. S. Steel Corporation, New York City; Mr. F. P. Wilson, Jr., General Electric Company, Schenectady, N. Y.; Dr. F. W. Sperr, Koppers Company, Pittsburgh; Mr. M. S. Sloan, New York Edison Company, New York City; Dr. Robert T. Haslam, Standard Oil Company of New Jersey, New York City; Mr. S. M. Kintner, Westinghouse Electric and Manufacturing Company, Pittsburgh, and Mr. Howard N. Eavenson, Eavenson, Alford and Hicks, Pittsburgh.

THE ADVISORY BOARD OF THE GUGGENHEIM MEMORIAL FOUNDATION

THE trustees of the John Simon Guggenheim Memorial Foundation announce that the following-named persons have been appointed members of the foundation's advisory board: Dr. Isaiah Bowman, director of the American Geographical Society; Dr. Wilbur L. Cross, editor of the *Yale Review* and dean of the Graduate School of Yale University; James Earle Fraser, sculptor, and Dr. Marjorie Nicolson, professor of English and dean of Smith College. Miss Nicolson, a former fellow of the foundation, is the second fellow to be appointed a member of the advisory board. The first was Professor Arthur H. Compton, of the University of Chicago, who won the Nobel prize in physics in 1928.

The advisory board consists of the following persons in addition to those mentioned above:

Dr. Frank Aydelotte, president, Swarthmore College, *chairman*.

Dr. Tucker Brooke, professor of English, Yale University.

Dr. Henry Seidel Canby, editor, *Saturday Review of Literature*.

Dr. Edward Capps, professor of classics, Princeton University.

Dr. Ada Louise Comstock, president, Radcliffe College.

Professor William Emerson, head of the department of architecture, Massachusetts Institute of Technology.

Dr. Frederick Carlos Ferry, president, Hamilton College.

Dr. Guy Stanton Ford, dean of the graduate school, University of Minnesota.

Dr. Charles Homer Haskins, professor of history, Harvard University.

Dr. Vernon Kellogg, permanent secretary, National Research Council.

Dr. Fiske Kimball, director of the Pennsylvania Museum.

Dr. Charles B. Lipman, dean of the graduate division, University of California.

Dr. Lafayette B. Mendel, professor of physiological chemistry, Yale University.

Dr. John C. Merriam, president, Carnegie Institution of Washington.

Dr. James F. Norris, professor of organic chemistry, Massachusetts Institute of Technology.

Dr. Louise Pound, professor of English, University of Nebraska.

Mr. Thomas Whitney Surette, lecturer in music, Harvard University Graduate School of Education.

Dr. Edwin B. Wilson, professor of vital statistics, Harvard University School of Public Health.

Dr. F. J. E. Woodbridge, professor of philosophy, Columbia University.

Since the establishment of the foundation by former United States Senator and Mrs. Guggenheim five years ago, 295 fellowships have been awarded. The foundation is a memorial to a son of the founders and its purpose in the words of Senator Guggenheim's letter of gift is to "advance human achieve-

ment by aiding students to push forward the boundaries of understanding and enrich human life by aiding them in the cultivation of beauty and taste." In accordance with these purposes the foundation offers fellowships, normally of the value of $2,500 a year, tenable abroad under the freest possible conditions for research in any field of knowledge and for creative work in any of the fine arts. The fellowships are open to men and women, whether married or unmarried, of every race and creed, on equal terms. The foundation has a capital fund of $4,500,000.

The trustees of the foundation, in addition to the founders, are Francis H. Brownell, Carroll A. Wilson, Charles D. Hilles, Roger W. Straus and Charles Earl.

SCIENTIFIC NOTES AND NEWS

AT the annual garden party of the New York Zoological Park on May 22 a bronze elephant, executed by the late Carl Akeley, was presented by Mr. Madison Grant on behalf of the executive committee to Professor Henry Fairfield Osborn as a token of his thirty-five years of service to the Zoological Society.

AT the annual commencement of the University of California on May 14 Mr. F. H. Seares, astronomer and assistant director of the Mount Wilson Observatory, was awarded the honorary degree of doctor of laws.

AT the forty-sixth commencement of the Case School of Applied Science on May 29 the doctorate of science was conferred on Dr. W. W. Coblentz, physicist, of the Bureau of Standards, and the doctorate of engineering on Mr. John Lyle Harrington, consulting bridge engineer, of Kansas City, Missouri. On Wednesday evening Dr. Coblentz addressed the Case chapter of the Society of Sigma Xi.

THE Museums of the Peaceful Arts, the American Institute and the New York Electrical Society gave a luncheon at the Hotel Astor on May 27 in honor of Sir William Henry Bragg, Fullerian professor of chemistry and director of the Royal Institution, London, and of the Davy Faraday Research Laboratory.

AT the recent annual general meeting of the British Chemical Society the prize and plaque to perpetuate the memory of Edward Frank Harrison, director of chemical warfare during the war, was presented to Dr. Reginald Patrick Linstead. This prize is awarded every three years to the chemist, not over 30 years of age, who is judged by a committee consisting of the presidents of the Chemical Society, the Society of Chemical Industry, the Pharmaceutical Society and the Institute of Chemistry to have made the most meritorious original contributions to chemical science during the previous five years. Professor J. F. Thorpe, president of the society, made the presentation.

DR. CARL LEAVITT HUBBS, curator of fishes in the museum of the University of Michigan and assistant professor in the department of zoology, has received the faculty award for a member of the teaching staff, not above the rank of assistant professor, who, in the opinion of a special committee of the university senate, has won special distinction in his field.

DR. HARRY N. EATON, of Elmira College, was elected to succeed Professor Edward S. C. Smith, of Union College, as president of the New York State Geological Association at the recent Schenectady meeting. Professor O. D. von Engeln, of Cornell University, was elected secretary to succeed Professor Harold L. Alling, of Rochester University.

THE Society for Experimental Biology and Medicine, New York City, has elected the following officers for the coming year: *President,* Peyton Rous; *vice-president,* D. J. Edwards; *secretary-treasurer,* A. J. Goldforb; *councillors,* Alfred E. Cohn, Leon J. Cole, C. F. Cori, A. B. D. Fortuyn, F. P. Gay, J. T. Halsey, A. C. Ivy, W. Ophüls, W. J. V. Osterhout, W. W. Palmer, F. H. Scott, H. D. Senior, P. A. Shaffer, F. M. Smith and G. B. Wallace.

MR. G. A. ORTH, executive of the American Car and Foundry Company and a member of the executive committee of the National Society of Safety Engineers, has been elected president of the New York chapter.

IT is announced in *Nature* that Sir Ernest Rutherford, president of the Royal Society, has been appointed chairman of the Advisory Council of the Department of Scientific and Industrial Research in succession to Sir William McCormick as from October 1. Professor V. H. Blackman will serve as chairman until October.

DR. R. G. AITKEN, who has been in charge of the active administration of Lick Observatory since July 1, 1923, with the title of associate director, has been named director, the appointment to date from July 1.

DR. W. A. RILEY, at present head of the department of zoology at the University of Minnesota, will become chief of the division of entomology in the same institution on July 1, when R. N. Chapman leaves to become director of the Experiment Station at the University of Hawaii.

PROFESSOR FRANZ SCHRADER, of Bryn Mawr Col-

lege, has been appointed professor of cytology in the department of zoology at Columbia University.

Professor R. Keith Cannan, of University College, London, has been appointed head of the department of biochemistry at the University and Bellevue Hospital Medical College, New York University. Professor Cannan was born in California. He has worked with Professor William Mansfield Clark in Washington and has taken part in teaching at Western Reserve University.

Dr. Nathan B. Eddy has resigned as associate professor of physiology and pharmacology at the University of Alberta to become associate professor of pharmacology at the University of Michigan.

The following promotions have been made at the University of Washington: Dr. John E. Guberlet, associate professor of zoology to a full professorship; Albert L. Seaman, from instructor in geology to assistant professor; Clinton L. Utterback, from assistant to associate professor of physics, and John Perry Ballantine from assistant to associate professor of mathematics.

Recent changes in and new appointments on the staffs of the Texas Agricultural Experiment Station and the Extension Service, Agricultural and Mechanical College of Texas, include J. N. Roney, division of entomology, Experiment Station, entomologist of the plant lice laboratory, Dickinson; S. E. Jones, entomologist of the Experiment Station, to succeed C. J. Todd, resigned to enter irrigation farming; H. P. Smith, for a number of years associate professor of agricultural engineering at the college, chief of the division of agricultural engineering in the Experiment Station.

Dr. Paul E. Weston has resigned as research chemist for the Roessler and Hasslacher Chemical Co., Perth Amboy, New Jersey, to accept a position as Senior Eli Lilly Research Fellow at Purdue University.

Dr. Horace B. English, professor of psychology at Antioch College, has accepted appointment as professor of psychology at Ohio State University. Dr. Clarence Leuba, lecturer in psychology at Bryn Mawr College, has been appointed associate professor of psychology at Antioch College in succession to Dr. English.

The J. T. Baker Chemical Company's fellowship in analytical chemistry, eastern division, has been awarded to Mr. Reuben Roseman, who will work at Johns Hopkins University under the direction of Professor W. M. Thornton, Jr., on a problem relating to the use of powerful reducing agents in volumetric analysis.

The regius chair of medicine in the University of Aberdeen, rendered vacant by the resignation of Professor Ashley Watson Mackintosh, has been filled by the appointment of Dr. Leybourne Stanley Patrick Davidson.

Professor F. Marion Lougee, of the department of chemistry, of Keuka College, who is on leave of absence for the semester, is engaged in research work at the University of London and will travel on the continent during the summer. Dr. Minnie A. Graham is in charge of the department during Dr. Lougee's absence.

Arthur Paul Jacot, of the department of biology of the Shantung Christian University, will spend the summer at the Marine Biological Laboratory of Sendai University, Asamuchi, northern Nippon, through the kindness of its director, Dr. Shinkishi Hatai, and a grant from the Elizabeth Thompson Science Fund, to study the moss-mites of the region and the scale characters of the mullets of those waters.

Dr. Aleš Hrdlička, of the U. S. National Museum, left Washington on May 5 for Alaska. This year's expedition will be devoted to the anthropologically practically unknown Kuskokwin River. Dr. C. E. Resser left on May 13 to resume his studies of the Cambrian stratigraphy of the Rocky Mountains. The first two weeks will be spent in the Grand Canyon, where in cooperation with the Carnegie Institution search for fossils in the pre-Cambrian strata will be made. Mr. J. N. B. Hewitt left on May 10 to continue his researches on the Iroquois, and Dr. F. H. Roberts, Jr., of the Bureau of American Ethnology, left on May 12, for a point twenty-five miles southwest of Zuñi to excavate a series of pit house ruins belonging to the earliest stages of the prehistoric pueblo people.

Professor J. H. Ashworth, head of the department of zoology of the University of Edinburgh, gave a lecture at the University of Michigan, May 12, on "The Nervous System of Annelids in Relation to Movement." This lecture was under the auspices of the department of zoology.

Dr. Roger Adams, professor of organic chemistry and director of the department of chemistry of the University of Illinois, delivered the Charles E. Dohme Memorial Lectures at the Johns Hopkins University, School of Medicine, on May 1, 2 and 3. The subjects were: A Survey of Various Important Contributions of Organic Chemistry to Medicine; The Use of Chaulmoogra Oil, Chaulmoogric Acid and its Constitution; Synthetic Homologs and Analogs of Chaulmoogric Acid and their Bactericidal Action.

Dr. Raymond C. Moore, professor of geology in the University of Kansas, recently gave an illustrated

lecture on the Grand Canyon of the Colorado in Arizona before an open meeting of the local chapter of Sigma Xi at the University of Nebraska.

THE annual address before the Virginia Chapter of Sigma Xi was delivered by Dr. C. E. McClung, professor of zoology, University of Pennsylvania, on May 16. At this meeting the President and Visitors' Research Prize of $100 was awarded for the best paper on research in the University of Virginia during 1929 to Dr. Carl C. Speidel, associate professor of anatomy, for his work on hyperthyroidism. At this meeting twenty new members were admitted to membership in the chapter.

DR. FRANK E. E. GERMANN was the guest speaker at the fortieth annual meeting of the Nebraska Academy of Sciences, meeting on May 9 and 10 under the auspices of the Peru State Teachers College, Nebraska. At the general session he spoke on "The Use of Physical and Physico-chemical Measurements in the Sciences" and at a joint session of the mathematicians, physicists and chemists on Saturday morning his subject was "Para Hydrogen."

THE twentieth meeting of the Australasian Association for the Advancement of Science was held in Brisbane during the week commencing May 28, under the presidency of Mr. E. C. Andrews, government geologist, Sydney. The local honorary secretary for the meeting is Dr. D. A. Herbert, the University, Brisbane.

ON May 3 and 4 the department of geology of Washington University, under the supervision of Vice-chancellor Walter E. McCourt, entertained the faculty and advanced students of the department of geology of the Missouri School of Mines at a luncheon and dinner. An opportunity was afforded for the visitors to go through the new geology building on the campus at Washington University and to take a short field trip in the vicinity of St. Louis. Those attending included Dr. and Mrs. C. L. Dake, Dr. H. A. Buehler, Dr. and Mrs. G. A. Muilenburg, Dr. and Mrs. J. Bridge and Dr. O. R. Grawe.

PLANS are being made at Northwestern University for a hospital at Chicago Avenue and Fairbanks Court, Chicago, which are said to be the culmination of more than eight years of negotiation for the complete reaffiliation of Wesley Memorial Hospital and Northwestern University. The main building of the new hospital, to be erected at a cost of $5,000,000, will be 18 stories in height and its tower will extend upward 12 more stories. It will have 600 beds. Its clinics, together with the existing facilities the university has in Passavant Hospital, will form on the McKinlock campus a complete medical center, capable of caring for almost 1,000 patients. The new hospital will be largely devoted to patients from salaried and wage-earning families, according to George W. Dixon, president of the board of trustees of Wesley Hospital. More than two thirds of the patients will be cared for at less than average cost, and many will be cared for free of charge. On the other hand, complete apartments, including three rooms, a kitchenette and bath, a heretofore unknown feature in hospital equipment, may be obtained during convalescence, at a cost of $100 a day.

THE dedication of the new central unit of the main engineering building of the Pennsylvania State College took place during the annual industrial conference, which opened on May 14. The building was erected and equipped at a cost of $350,000 as part of the four-year $4,250,000 building program whose completion will be celebrated this Fall on the occasion of the seventy-fifth anniversary of the founding of the college. Speakers at the dedication included Messrs. N. F. Dougherty, of the General Motors Corporation; L. K. Sillcox, vice-president of the New York Air Brake Company; F. J. Chesterman, vice-president of the Bell Telephone Company of Pennsylvania; R. L. Streeter, vice-president of the Pennsylvania Railroad, and Dean Sackett.

AT a general meeting of the members of the Royal Institution held on May 7, Sir Robert Robertson, treasurer and vice-president, in the chair, it was announced that the managers had received and accepted from the trustees of the Rockefeller Foundation an offer of a donation of £20,000 for endowment of research in the Davy Faraday Laboratory, on condition that the sum of £50,000 for the same purpose should be secured by the Royal Institution from other sources before June 30, 1933.

THE Rockefeller Foundation has given $150,000 to the University of the Philippines to construct a building to house the university's Graduate School of Hygiene and Public Health. A condition that the university provide a suitable site and an annual budget of $40,000 has been met. The University of the Philippines is owned and operated by the state. It has about 5,000 students, most of them Filipinos.

THE Permanent Science Fund held by the Boston Safe and Deposit Company as trustee has made through the Boston Academy of Arts and Sciences the following appropriations: To Professor Harlow Shapley, of Harvard University, $500 to be devoted to the employment of an experienced assistant in measuring periods and light curves of variable stars of the Cepheid class, and $1,000 for the employment of an expert assistant in a systematic study of eclipsing binaries by means of the Harvard plates; to Professor

C. T. Brues, of Bussey Institution, Harvard University, $600 for the purpose of photographic equipment and materials to aid in a study of the movement of insects; to Professor C. I. Reed, of the University of Illinois College of Medicine, $500 for use in a study of the influence of irradiated ergosterol on metabolism, and to Professor J. Leroy Conel, Boston University School of Medicine, $500 to be used for the collection of embryos of the hagfish, *Bdellostoma stouti*, necessary for the completion of researches on the development of the brain.

THE Geographic Society of Chicago has inaugurated a Research Series of lectures arranged by the research committee, of which Professor William H. Haas, of Northwestern University, is chairman. In announcing this series of lectures the society continues the policy which it adopted last year. The essentials of this policy are (1) that the lectures be given by men of recognized standing in scientific geography, (2) that the lectures represent field investigations of significant problems and (3) that the lectures be given for the first time before the society. The lectures are held in Fullerton Hall, Art Institute of Chicago. The titles for 1930 are as follows: March 19—Dr. Preston E. James, the University of Michigan, "Vicksburg: A Study in Urban Geography." April 23—Dr. Charles C. Colby, the University of Chicago, "Regional Integrity and Intra-regional Variations as Evidenced by Peace River Communities." May 19—Dr. Derwent S. Whittlesey, Harvard University, "The Lancaster Community: A Study of Land Occupance in Northern New England Sequent to the Epoch of Farm Abandonment."

Two new funds have been made available to the National Research Council for research. One of these, an appropriation of $22,500 from the Spelman Fund, is for the continuation of the work of the committee of the Division of Anthropology and Psychology on child development for the two fiscal years, 1930–31 and 1931–32, at the rate of $10,000 per year, and includes also $2,500 to cover the quarter from the close of the present fiscal year of the committee on March 31, to the beginning of the regular fiscal year of the council on July 1. The second fund is an appropriation of $18,800 from the Commonwealth Fund for the support of the work of the joint committee of the Divisions of Medical Sciences and of Biology and Agriculture on infectious abortion for a three-year program of study on this pernicious disease. This money will be applied toward the maintenance of a cooperative central laboratory at the Michigan State College of Agriculture and Applied Science for the culture and study of strains of the organism, *Brucella*, the cause of the disease.

MR. DANIEL C. JACKLING, of San Francisco, president of the Utah Copper Company, has made provision for the establishment at the Missouri School of Mines and Metallurgy at Rolla, of which he is a graduate, of the Jackling Foundation for education in the sciences and arts pertaining to the mineral industry, its purpose being to aid worthy students by means of generous loan funds and to provide scholarships and special educational features not ordinarily provided for at state schools. The fund, through contributions already made and to be made by Mr. Jackling, may eventually amount to $600,000. Of this amount $100,000 is to be used as a loan fund, and the income from $500,000 for scholarships and special educational purposes. About twenty years ago Mr. Jackling established the Jackling Loan Fund at the School of Mines, which has already given assistance to three hundred students.

ACCORDING to the London *Times* at a hearing before Bromley justices it was ruled that the British Association must pay taxes on Down House, Darwin's old home. Mr. O. J. R. Howarth, secretary of the association, who lives at Down House, said that in 1928 Sir Arthur Keith, then president of the association, made a deed for the preservation of Down House. Mr. George Buckston Browne then acquired the property at his own expense and had it transferred to the British Association, together with an endowment for its maintenance as a memorial to Darwin. He intended that the house and grounds should be used for the benefit of science. The witness went to live there in September, 1929. He was the servant of the association, and had a large number of duties to perform. Cross-examined by Mr. Done, the witness said he carried on his duties at Burlington House and at Down House. Before Down House was acquired all the work was done at Burlington House. The secretarial staff was kept at Burlington House. The staff at Down House consisted of two custodians and a gardener. A very substantial correspondence was addressed to him at Down House. Mr. Lane submitted that Mr. Howarth resided on the premises exclusively to carry out the objects of the association. Mr. Done held that Mr. Howarth's main object in living at Down House was residential. The chairman, in giving the decision of the bench, said they were of opinion that the occupation of part of the premises by Mr. Howarth under the terms of the arrangement between him and the association was such that, although the association was exempt under the Scientific Societies Act, 1843, the premises could not be considered to be occupied exclusively for the transaction of the business of the association or for the carrying out of its objects.

THE British Secretary of State for the Colonies

has asked the High Commissioner for the Malay States to appoint Mr. Theodore Hubback, lately honorary Game Warden in Pahang, to report on the whole question of the wild fauna of Malaya. It is contemplated that a high official of the Federated Malay States government should be associated with him as assessor. In general the object of the appointment is to make regulations for the preservation of wild life, including the administration of national parks, wild life refuges and game reserves, and to suggest methods for dealing with any damage to agriculture done by wild animals.

DISCUSSION

THE "GIBBS PHENOMENON"—A MISNOMER

A FOURIER series corresponding to a function, $f(x)$ of period 2π, and convergent over an interval on the X-axis over which $f(x)$ is continuous, under very general conditions converges uniformly over any closed subinterval. If, however, $f(x)$ has a discontinuity of the kind sometimes called a "finite jump" in an interval over which it is otherwise continuous, convergence is not uniform over any neighborhood of this point. The approximation curves, $y=s_n(x)$, have maxima and minima whose distances from the limit curve, $y=f(x)$, do not approach zero when n becomes infinite, although the abscissa of each such extreme value identified by counting from the discontinuity approaches the abscissa of the discontinuity. Briefly, this is what is known as the "Gibbs phenomenon." It seems to have been first noticed by Gibbs and was briefly described by him in a note in *Nature*[1] published in 1899. The name was applied by Bôcher in his widely read paper[2] on Fourier series. The approach by Gibbs and Bôcher and generally by subsequent writers was graphical, and the "phenomenon" should be thought of as a graphical one.

However, this "phenomenon" is in no way limited to Fourier series but is characteristic of the approximation curves of many non-uniformly convergent series. In two papers[3] now classical in the theory of uniform convergence Osgood treats with exhaustive care the behavior of "peaks" in the neighborhood of points of non-uniform convergence. He does not explicitly study Fourier series. But the behavior of approximation curves is a general problem and it is treated by Osgood in a general way. There is nothing essential to the so-called "Gibbs phenomenon" which he does not study and illustrate by examples. His approach is primarily graphical and his papers antedate the note of Gibbs by three years. His treatment is careful and thorough as against the somewhat casual character of Gibbs's note.

If the name of any individual is to be applied to the behavior of "peaks" in the neighborhood of points of non-uniform convergence it should be the name of Osgood. The term Gibbs phenomenon has been applied to such behavior in the study of series of Bessel's[4] functions. Even if the name is retained for Fourier series, I do not see that it is justified for other series. Its only justification is that Gibbs remarked for Fourier series a situation the essentials of which were already widely known for other series.

TOMLINSON FORT

LEHIGH UNIVERSITY,
JANUARY, 1930

[1] Josiah Willard Gibbs, *Nature*, 59: 606.

[2] Maxime Bôcher, *Annals of Mathematics*, 7: 129, 1906.

[3] William Fogg Osgood, "Non-uniform Convergence and the Integration of Series Term by Term," *Amer. Jour. of Math.*, 19 (1897), read August 31, 1896; "A Geometrical Method for the Treatment of Uniform Convergence and Certain Double Limits," *Bull. Amer. Math. Soc.*, 3: 59, November, 1896, read August 31, 1896.

[4] For example, C. N. Moore, *Bull. Amer. Math. Soc.*, 34: 414, 1928.

THE PROBLEM OF SALINE DRINKING WATERS

IN the February 21, 1930, issue of SCIENCE, V. G. Heller and C. H. Larwood reported experiments on the deleterious effects of certain saline drinking waters. In the course of a ground-water survey of northwestern Minnesota a few years ago, the writer had opportunity to observe in the field similar effects from waters of moderate concentrations, mostly lower than those reported by Heller and Larwood. The worst waters appeared to be those rich in sulphates. The waters are commonly (though often incorrectly) referred to as "alkali" waters. The sulphates in some waters are accompanied by true alkali, *i.e.*, soda or potash, but lime and magnesia generally are more abundant. Some are associated with high chlorides and others are not.

These high sulphate waters in Minnesota are common in the till-plain just east of the glacial Lake Agassiz basin and in the lake-bed itself (now the Red River Valley). Thus nine representative samples taken from various depths and localities in Stevens County range in salinity from 664 to 2,800 p.p.m., and the average of the nine is 1,575 p.p.m. anhydrous salts. The minimum sulphate is 29 per cent., the maximum 58 per cent. and the average 49 per cent., or approximately 770 p.p.m. The averages of the other main constituents are: Ca 14 per cent., Mg 5 per cent., Na 11 per cent., K 2 per cent., CO_3 (including HCO_3, recalculated) 16 per cent., Cl 1 per cent. In four of the nine samples, Na is more abundant than Ca. The low amount of chloride is noteworthy.

In the Cretaceous waters which are tapped by drilling in the Red River Valley farther west, sul-

phates and chlorides (apparently connate) are both abundant. Thus water from a city well at Wheaton, Minnesota, shows Ca and Mg 1 per cent., Na 33 per cent., K 4 per cent., CO_3 4 per cent., SO_4 28 per cent. and Cl 30 per cent.; total salinity, 2,794 p.p.m. This is a typical soft salty water of the region. Similar waters occur in the basal sand of the Cretaceous rock system northward to the Canadian boundary, but with a salinity as high as 10,000 p.p.m. or more. Toward the east these waters are diluted and become sodium or calcium bicarbonate waters. The waters from the glacial drift above the Cretaceous beds are bicarbonate solutions of Ca or Na, but many show high sulphates also. Waters from wells ending in the clays of glacial Lake Agassiz are notoriously high in sulphates, so that they have a bitter taste and drastic purgative effect on the drinker. In one case a 12-inch bored well 45 feet deep furnishes water containing 2,104 p.p.m. SO_4 in a total salinity of 3,600 p.p.m. As an extreme, another 80-foot well furnishes water with 3,590 p.p.m. SO_4 in a total salinity of 5,756 p.p.m.

The drastic cathartic action and the weakening effect of these natural solutions of Epsom and Glaubers salts on man and on live stock are well known in the region. Some persons believe that disorders of kidneys and bladder also result, but that effect is not established. It seems true though that no matter how well they are fed, cattle and hogs can not be fattened for market while they drink such water. Indeed, the case is even worse. The cattle develop a run-down, ragged appearance and many eventually weaken and die prematurely. The principal difficulty in such cases seems to be that a degeneration of the bones sets in, so that most of the lime is abstracted from them. These bones are reduced to gristle that can be tied in knots and easily punctured with a knife. Calves are stunted in growth and many never mature at all. The cows develop strange appetites for bones, leather, wood, etc. The condition is alleviated but perhaps not cured by feeding bone-meal or ground limestone.

Altogether about one fourth of the State of Minnesota is affected in some degree by this problem. Furthermore, the observation of cattle from Dakota and Montana, where similar waters are known, suggests that the difficulty is really wide-spread but has not been properly diagnosed. With the present trend toward "diversified farming" involving cattle-raising and dairying, a considerable territory faces a critical problem. It seems probable that people using such waters are affected in the same way as cattle, but perhaps in different degree, so that questions of human physiology and diet also are involved.

It is to be hoped that the experimental work of Heller and Larwood will be continued, and that the effect on the equilibrium of body calcium may be studied in particular, because the problem has a large economic bearing.

IRA S. ALLISON

OREGON STATE COLLEGE

A SURVEY OF THE PHYTOPLANKTON AT ERIE, PENNSYLVANIA

IN a recent number of SCIENCE[1] Mr. Paul R. Burkholder outlined briefly the scope of the biological survey of Lake Erie which was carried out during the summers of 1928 and 1929 through the cooperation of the U. S. Bureau of Fisheries, Buffalo Society of Natural Sciences, N. Y. State Conservation Department, Buffalo Health Department and the fish and game departments of Ohio, Ontario and Pennsylvania. Attention should be called, also, to similar investigations being carried on at Erie, Pennsylvania, by graduate assistants in the University of Pittsburgh appointed for that purpose. The present note refers only to the work carried on by the assistant in the botanical department of the university.

Early in the spring of 1929, Mr. Herbert Graham began quantitative and qualitative studies of the raw Lake Erie water taken in at the large city waterworks intake crib situated out in the lake about two miles from the shore of Presque Isle and about three miles out from the main shore at Erie. The water is taken into this main at a level of about six feet above the lake-bottom and twenty-four feet below the surface of the water. Generally, two samples of this water were studied each week, the organisms identified and their abundance estimated. In the late spring Mr. Graham left to become a member of the staff of the ill-fated *Carnegie*, being succeeded by Mr. Russell Y. Gottschall, who has continued the investigation.

The notable results of this study consist mainly in that there is now a continuous record of the phytoplankton organisms throughout the whole year, based on studies of about 250 samples and including about 65 organisms determined as to species and various others as to genera. It is believed that this study will thus supplement in a very important way the more general biological survey carried on only from May to September. The Erie samples are also much more productive, as a larger number of the organisms are caught by the lake-sand filter method used than by the tow-net and bottle method.

Being an expert bacteriologist, Mr. Gottschall has extended the studies to cover the bacterial flora of Erie Bay, as well as its general phytoplankton, and

[1] SCIENCE, 75: 288, March 14, 1930.

has carried on a number of oxygen determinations, particularly during the colder months.

O. E. JENNINGS

UNIVERSITY OF PITTSBURGH AND
CARNEGIE MUSEUM

THE VITALITY OF BURIED SEEDS

Two long-term seed tests have been started in the United States, and are still in progress. The first was started by Dr. W. J. Beal at the Michigan Agricultural College. In this test, one half of the kinds germinated after forty years. The other was begun by the Seed Laboratory, Bureau of Plant Industry, U. S. Department of Agriculture, in 1902 at Arlington Farm, Virginia. At the end of twenty years, fifty-one of the 107 kinds planted were viable. Other sets of seeds in both tests remain buried and will be taken up and germinated at intervals. These two tests have been particularly suggestive with respect to revegetation and crop rotation in relation to weed control.

It now seems desirable to put down a more comprehensive long-time series of tests to determine the effect of typical soil and climatic conditions on the length of time seeds will remain alive when embedded in the soil. Such a test is now being planned by the Seed Laboratory, Bureau of Plant Industry, U. S. Department of Agriculture. The success of the project will require the cooperation of many interested organizations and individuals. Suggestions as to characteristic areas with reference to both soil and climate will be welcomed as well as suggestions as to the kinds of seeds of particular interest in these typical localities. It is expected that the seeds used will be of the crop of 1931, and that they will be placed in the ground during the fall of that year.

E. BROWN

SPECIAL CORRESPONDENCE

RESEARCH AT THE MELLON INSTITUTE DURING 1929–30

SINCE Mellon Institute was established in Pittsburgh nineteen years ago, about thirty-five hundred companies have benefited directly, either as individuals or as members of industrial associations, by the work carried out under the institution's industrial fellowship system. Robert Kennedy Duncan, the originator of this procedure, envisioned as its goal ideal industry, which would "give to all broader opportunities for purposeful lives." The double function of the institute as a technical experiment station and as a training school for industrial scientists is manifested by the successful products and processes worked out under its auspices and by the regiment of earnest researchers who have here gained knowledge and experience that they are now applying in wider fields.

In his seventeenth annual report to the institute's board of trustees, just issued, Director Weidlein has summarized the progress during the fiscal year ended February 28, 1930. A quantitative measure of the activities is afforded by the funds contributed by the industries in this period for the support of research, which reached the sum of $929,109.02, showing an increase of 16 per cent. over the preceding year. At the close of the year, sixty-one problems were under investigation, twenty-one by multiple industrial fellowships and forty by individual industrial fellowships. Eight studies are being supported by industrial associations. Five additional fellowships will begin work during the spring. One hundred and forty-three industrial fellows and fellowship assistants are carrying on the experimental work. During the calendar year 1929, publications by members of the institute included seven bulletins, fifty research reports and fifty-nine other papers. Sixteen United States patents were issued to industrial fellows.

The institute expends its income not only in conducting research for the industries and in the extension of its library and experimental facilities, but also in sustaining its department of research in pure chemistry and in supporting certain investigations of general importance to public welfare, such as, for example, the comprehensive study of air pollution now in progress.[1] The fellowship on pure research, maintained since 1915, was perpetuated in 1927 as a separate department. In this way the institute is giving constantly increasing attention to the encouragement of research on fundamental chemical problems. This attitude is the result of altruistic motives and of the realization that such studies are necessary as a background and stimulus for industrial research. Since this department was established, it has published nineteen papers on various subjects in pure organic chemistry. Most recently its work has been on the acidic carbohydrates occurring in plants.

Of the sixty-one fellowships now active, twenty-nine, approximately half, have been in operation for five years or more. Fifteen have completed more than ten years of work. These facts bear witness to the growing realization by industrialists that long-time, fundamental research is profitable.

Information concerning the subject-matter and progress of many of the fellowships is not releasable. The following developments during the year are

[1] On the institute's air-pollution investigational program, see L. W. Bass, SCIENCE, 70: 186, August 23, 1929.

among those of which the institute is privileged to speak. The Portland cement fellowship has carried on a cooperative study of bricklaying in the course of which 350 experimental walls and two small experimental houses have been built; the project is being conducted along broad but thoroughly practical lines with the advisory help of a group of brick manufacturers, construction engineers, architects and brickmasons. A second new breakfast food has been developed by the food varieties fellowship, and the work on carbonated beverages has resulted in valuable contributions to the technology of extract manufacture in this industry. The studies on cooking utensils have shown that corrosion during cooking operations is insignificant in degree and does not contribute in any way to food poisoning or other diseases. The investigation of sleep has been one of the outstandingly productive projects of the institute. A new high-temperature insulating material has been worked out by the fellowship on heat insulation, and the contributions of the vitrified sewer-pipe fellowship have led to important economies in fuel consumption in this industry. The laundry and petroleum production fellowships have been partly transferred to the donors' organizations, certain of the fundamental problems remaining in the institute. Comprehensive studies on iodine are now in progress.[2] The process for the chrome-plating of aluminum worked out in the institute is now being applied commercially on a large scale. The organic synthesis fellowship has been remarkably successful in developing new, commercially valuable compounds for a wide variety of industrial uses. The plastic vinylite resin is one of the latest additions to this large list of products from hydrocarbon gases.

Ten fellowships—those on surgical supplies, felt hat manufacture, aluminum plating of chromium, licorice, beds, gum, industrial alcohol and stearic acid, and two fellowships on cast iron—completed their investigational programs during the fiscal year. Nine new fellowships became active: rosin oil, garment, hemp paper, steel treatment, can, nicotine, wood by-products, fatty acid uses and oxygen. The institution has been obliged, because of lack of space, to postpone the acceptance of several important problems.

The 143 men composing the industrial fellowship personnel at the end of the fiscal year hold degrees from seventy-eight universities and colleges.[3] Of the 109 men with the rank of senior industrial fellow or industrial fellow, 46 have the Ph.D. or Sc.D. degree, and 22 others have a master's or advanced engineering degree.

Since 1925 the institute has sponsored each year a series of radio talks on late progress in science and technology, broadcast from the University of Pittsburgh Studio of Station KDKA. In a similar manner the importance of science to the nation's welfare is kept before the public by means of public addresses and newspaper and magazine articles prepared by members of the institute.[4]

During the nineteen years since the establishment of Mellon Institute at Pittsburgh, the amount of money appropriated to it by companies and associations was $6,749,273. The total contributions to scientific literature comprise 15 books; 96 bulletins; 528 research reports; 849 other articles, and 407 United States patents.

Lawrence W. Bass,
Executive Assistant

Mellon Institute of
Industrial Research

QUOTATIONS

A NEW HEALTH INSTITUTE

Blanketed by the debates over the tariff, the treaty and the Supreme Court, a bill has slipped through Congress, almost unnoticed, which will have a place in governmental history. It sets up a National Institute of Health. This has long been the dream of Senator Ransdell, of Louisiana. In realizing it he has had the support of the American Medical Association, the American Public Health Association and various scientific bodies. His bill has the endorsement of Secretary Mellon and will doubtless be signed by President Hoover, who has always taken a special interest in scientific research and in government agencies to further it.

Under the Ransdell bill the Hygienic Laboratory is made the nucleus of the new establishment, which will be devoted to the purpose of inquiring into the cause, prevention and cure of diseases. The Treasury Department is specifically authorized to accept gifts from private sources for the furtherance of these investigations, much as the Library of Congress was authorized some years ago to accept donations in its field. A system of fellowships in scientific research has been devised in order to secure the proper per-

[2] On the institute's researches on iodine, see L. W. Bass, Science, 71: 37, January 10, 1930.

[3] On the institutional sources of industrial research men, see W. A. Hamor, Science, 51: 625, 1920; 64: 380, 1926.

[4] For a full account of the educational activities of Mellon Institute, see W. A. Hamor and L. W. Bass, *J. Chem. Education*, 7: 81, 1930.

sonnel and to encourage men and women of exceptional proficiency to devote their efforts to the war on disease. While a great deal has been accomplished by the universities, medical schools and endowed institutions, these efforts heretofore have often lacked coordination. The idea is to make the institute "a great cooperative scientific organization in which leading experts in every branch of science will be brought together and given an opportunity to work in unison for the purpose of discovering the natural laws governing human life."

The country's annual "human repair bill" runs to about $1,000,000,000. That takes no account of loss of time or loss of life from preventable disease. Congress has appropriated vast sums for research in crops and live stock, in mines and minerals, and in the problems and processes of industry, but it has done comparatively little to further the cause of human health. The workers in the Hygienic Laboratory have shown what could be done even with meager funds. With the far larger resources that the National Health Institute will ultimately command, it should be capable of doing great things.—*The New York Times.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN IMPROVED DESIGN FOR A SIMPLE LABORATORY PLANT-DRIER

THOUGH heated air, with the aid of a variety of devices, is commonly utilized by botanists for drying their specimens rapidly while in the field, the older and much slower process of curing under pressure, by the changing of absorbent pads or blotters, is still very widely used in the college and high-school laboratories of the country. That teaching botanists have not more generally taken advantage, both for themselves and for their students, of the time-saving and trouble-eliminating method of heat-curing is undoubtedly due quite as much to the fact that no entirely satisfactory apparatus has been made available as to any prejudice against the method.

The writer, during the past nine years, has been constantly under the necessity of accomplishing quickly in his laboratory the curing of botanical specimens collected under field conditions that prohibit the use there of either blotters or heaters. To overcome this difficulty, various types of driers have been made and tested in the laboratory, where the specimens are sent as soon as possible after being collected, and finally a satisfactory drier has been obtained. It was built according to the plan shown in the accompanying drawing, as a permanent piece of laboratory equipment.

This drier, though developed independently, is similar in many ways to an apparatus described by Dr. H. S. Jackson in the "Report of the New York State Botanist for 1924,"[1] but it embodies several improvements and advantageous modifications not found in Dr. Jackson's drier.

This newly designed plant-drier consists essentially of a four-sided wooden box set on legs at a convenient height and provided with two electric lamps to furnish the needed heat. It is open at the top, but the bottom is closed by a galvanized iron pan which, while being perforated with a number of holes to admit cold air, retains and stores heated air beneath the pack of specimens.

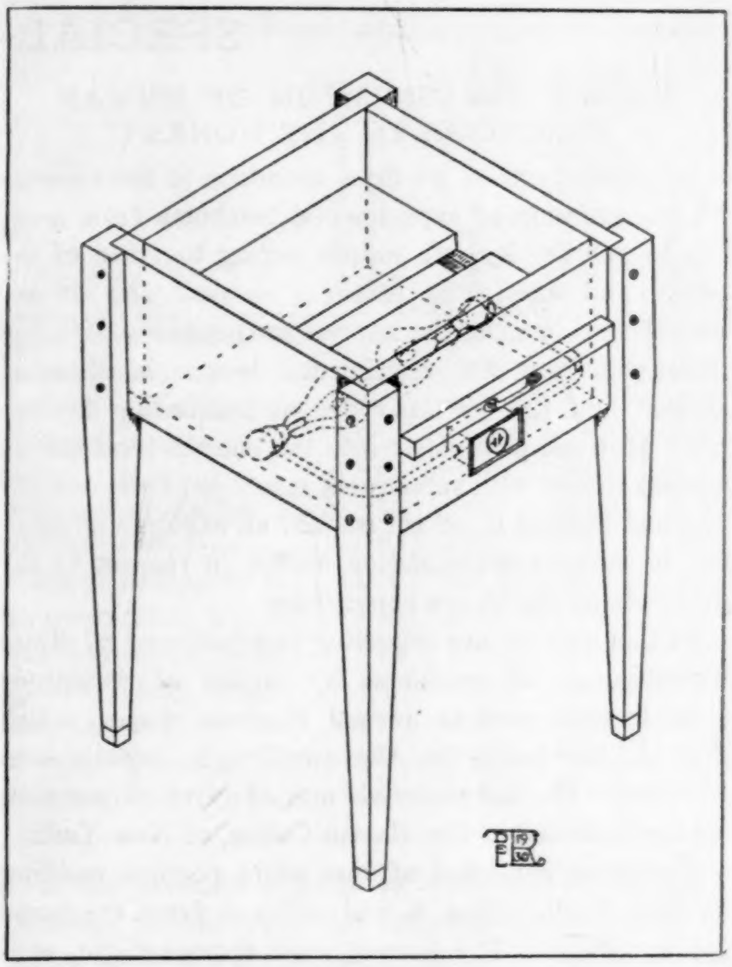

FIG. 1

A narrow ledge fastened around the inner walls of the box, halfway between top and bottom, serves as a support for the pack of specimens; and two sliding shelves, which rest on this ledge and are adjustable to the size of the pack, prevent the escape of heated air along its sides.

Except the legs, which are of oak, all wooden parts are made of yellow poplar, in order to reduce warping to a minimum. When the usual black laboratory stain is applied to the box, inside and out, and to the shelves, and when the legs are finished with orange

[1] New York State Museum Bul. 266, pp. 99–101, 1925.

shellac and clear varnish an appearance is obtained that is both pleasing and in harmony with other laboratory furniture.

The specimen pack is prepared for drying, as in other cases where heated air is utilized, by separating the specimens from each other with corrugated straw-board, the corrugations running, of course, the short way of the pack, so as to be vertical when the pack is set in the drier. After being strapped tightly between press-boards or lattices, the pack is set on edge in the drier, the sliding shelves adjusted to its sides and the electric current turned on. The rate of drying can be controlled by the size of lamp used.

In our hands, this drier has proved very satisfactory indeed. It is, first of all, a complete and independent unit. As it occupies but little space, it can be conveniently installed in a crowded laboratory. Requiring only to be connected with an electric current, it is always ready for use, and large or small sets of specimens can be handled in it with equal facility. A full pack of wet aquatic plants can be dried in from eight to ten hours by using two 100-watt lamps. There is, moreover, no danger of fire, and the specimens are not subjected to scorching or overheating.

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SPECIAL ARTICLES

DIRECT TRANSMISSION OF HUMAN TRACHOMA TO THE MONKEY

IN previous notes we drew attention to the successful transmission of experimental trachoma from monkey to monkey by (*a*) simple caging together of infected and uninfected *Macacus rhesus*,[1] (*b*) by repeated swabbing of the normal conjunctivae with the secretions from the experimental lesions in *Macacus rhesus*[2] and (*c*) by the repeated instillation of cultures of *Bact. granulosis* into the conjunctival sac of normal rhesus with subsequent massage of the eyelid.[2] The last method is, of course, not an example of monkey to monkey transmission except in respect to the principle of eye to eye conveyance.

In this note we are reporting two instances of direct transmission of trachoma by means of secretions from human cases to normal *Macacus rhesus*, which showed, previously to the swabbings, smooth conjunctivae. For the materials and effective cooperation we are indebted to Dr. Martin Cohen, of New York.

The cases consisted of two white persons residing in New York. Case A had suffered from trachoma for ten years. The lesions were characteristic, consisting of granulations, extensive scar formation and pannus. Case B had suffered from the active disease for two years. The lesions consisted also of granulations, scars and pannus.

The secretions from each case were taken on cotton swabs and transferred directly, by gentle rubbing, to the smooth conjunctivae of each of three monkeys. Nine swabbings were made from man to monkey in Case A and seven in Case B.

Thirteen days after the last swabbing from Case A, one monkey showed granular lesions of experimental trachoma, and thirteen days after the last transfer from Case B the three respective monkeys presented typical granulomatous changes.

Conjunctival tissue was removed from Case A for curative purposes by Dr. Cohen and employed for direct subconjunctival injections in three further normal *Macacus rhesus* presenting smooth conjunctivae. Within four to ten days, all three developed granular lesions of experimental trachoma. The excised tissue was also employed for bacteriological study. Cultures of *Bact. granulosis* were isolated, and these when injected subconjunctivally into three normal monkeys induced in all experimental trachomatous changes in nine to eleven days.

Finally, granulomatous tissue removed from the monkey infected by swabbing from Case A yielded cultures of *Bact. granulosis*.

The direct transmission of trachoma to monkeys has already been effected by several investigators,[3] but the present experiments are the first in which both transmission and the isolation of *Bact. granulosis* have been successful with the same trachomatous material.

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[1] J. R. Tyler, SCIENCE, 70: 612, 1929.

[2] P. K. Olitsky and J. R. Tyler, SCIENCE, 71: 263, 1930.

[3] For literature see: H. Noguchi, *Jour. Exper. Med.*, Supplement No. 2, 1928, xlviii; and V. Morax and P. J. Petit, "Le Trachome," Paris, 1929.

ASSOCIATION AND CONSTITUTION

THE study of the properties of compounds has unfortunately not yet made it possible to predict the properties of associated compounds with any degree of success. It now appears that the association as measured by the fluidity method varies regularly in a given homologous series, so that the association itself

may be calculated, thus permitting the calculation of other properties dependent upon the association. It is found that groups causing association, such as carboxyl, hydroxyl, sulphydrate, etc., are most active at the end of a paraffin chain and are less active as the paraffin chain is shortened or as the active groups are moved toward the center of the paraffin chain. These effects may be incorporated in a formula.[1]

THE OBSERVED AND CALCULATED ABSOLUTE TEMPERATURES REQUIRED TO GIVE A FLUIDITY OF 100 RHES TO VARIOUS ACIDS, WITH THE PREDICTED ASSOCIATIONS

Substance	Predicted association at φ = 100 Rhes	Predicted absolute temperature to produce φ = 100 Rhes	Observed absolute temperature to produce φ = 100 Rhes	Percentage difference
Formic acid	2.225	325.5	324.7*	0.2
Acetic acid	1.841	304.9	305.7*	0.3
Propionic acid	1.816	298.8	300.0*	0.4
Butyric acid	1.572	321.0	320.2*	0.2
Valeric acid	1.527	341.3	342.0*	0.2
Caproic acid	1.482	359.8	361.3*	0.4
Heptylic acid	1.438	376.9	377.5	0.2
Caprilic acid	1.393	392.0	381.7*	2.7
Lauric acid	1.215	435.7	435.7	0.0

* Fluidity not measured by the authors.

THE OBSERVED AND CALCULATED ABSOLUTE TEMPERATURES REQUIRED TO GIVE A FLUIDITY OF 100 RHES TO VARIOUS ALCOHOLS TOGETHER WITH THE PREDICTED ASSOCIATIONS

Substance	Predicted association at φ = 100 Rhes	Predicted absolute temperature to produce φ = 100 Rhes	Observed absolute temperature to produce φ = 100 Rhes	Percentage difference
Methyl alcohol	2.097	272.0	263.2*	3.2
Ethyl alcohol	2.001	298.1	302.9*	1.6
Propyl alcohol	1.906	320.8	329.2*	2.6
Isopropyl alcohol	1.839	309.5	324.3*	4.8
Butyl alcohol	1.811	339.7	339.7*	0.0
Isobutyl alcohol	1.778	333.6	342.2*	2.6
Trimethyl carbinol	1.711	321.0	334.3*	4.1
Amyl alcohol	1.649	341.2	349.2*	2.3
Amyl (inactive) alcohol	1.682	348.0	349.2*	0.3
Dimethyl-ethyl carbinol	1.582	327.3	336.0*	2.7
Allyl alcohol	1.906	320.8	311.2*	2.7
n-Heptyl alcohol	1.525	374.4	362.3	3.2
n-Octyl alcohol	1.430	378.7	376.7	0.5

* Fluidity not measured by the authors.

The following tables will show the association as calculated by formula for certain compounds and also the temperatures required to give these compounds a fluidity of 100 rhes, the fluidity of water at 20° C. In the case of the mercaptans, the fluidity has, for convenience, been taken as 200 rhes.

THE OBSERVED AND PREDICTED ABSOLUTE TEMPERATURES REQUIRED TO GIVE A FLUIDITY OF 200 RHES TO VARIOUS MERCAPTANS TOGETHER WITH THE PREDICTED ASSOCIATIONS

Substance	Predicted association at φ = 200 Rhes	Predicted absolute temperature to produce φ = 200 Rhes	Observed absolute temperature to produce φ = 200 Rhes	Percentage difference
n-Ethyl mercaptan	1.118	250.0	247.5	1.0
n-Propyl mercaptan	1.107	272.0	273.5	0.6
n-Butyl mercaptan	1.095	293.2	293.1	0.0
n-Pentyl mercaptan	1.084	314.3	315.7	0.4
n-Hexyl mercaptan	1.072	334.5	335.8	0.3
n-Heptyl mercaptan	1.061	354.5	355.8	0.4
n-Octyl mercaptan	1.049	373.7	373.7	0.0
n-Nonyl mercaptan	1.038	392.7	389.7	0.8
Propane thiol - 2	1.082	265.8	269.0	1.2
Pentane thiol - 2	1.055	305.8	301.1	1.5
Hexane thiol - 2	1.041	324.8	321.9	0.9
Heptane thiol - 2	1.027	343.1	342.3	0.2
Octane thiol - 2	1.013	360.8	360.5	0.8
Nonane thiol - 2	1.000	378.3	378.3	0.0

If one excludes caprilic acid, the average deviation between the observed and calculated values for the acids is only 0.2 per cent., which is less than one tenth of the deviation shown by caprilic acid, so that we propose to prepare further samples of this substance in order to learn whether this difference is real or not. The average deviation with the thirteen alcohols is somewhat higher, averaging 2.3 per cent. If we include twenty-two different isomeric octyl alcohols, the deviation is 1.2 per cent. The average deviation for fourteen mercaptans is 0.6 per cent. Therefore the average deviation for fifty-seven calculated substances is 0.9 per cent.

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[1] See Eugene C. Bingham and Logan B. Darrall, *J. of Rheology*, 1: 174, 1930.

THE NATIONAL ACADEMY OF SCIENCES. III

Bending of curved tubes: William Hovgaard. This paper is an abstract of reports on a series of tests with curved tubes, such as are used as expansion bends in steam piping. The theoretical investigation, the tests and their analysis were carried out by the author during the years 1925 to 1929. The study began with the development of formulas for determining the deflections and stresses in such pipes when they are subject to bending. Suppose, for instance, that a bending couple, tending to increase the curvature, is applied to a pipe bend. The stress forces will then cause a small deformation of the transverse circular section which takes the form of an oval with its minor axis in the plane of bending. Hereby the material farthest from the neutral axis is largely relieved of longitudinal stresses, and the maximum values of these stresses, instead of occurring at the top and bottom of the section, as in the bending of a solid bar, occur at points much nearer to the neutral axis. The result is that equilibrium between the external bending moments and the internal stress couples will not be established until the bend has taken an angular deflection much greater than in the absence of sectional deformation. It follows that also the linear displacement of the ends of the pipe is much greater, a point which is of great importance to the engineer in the bends used in steam pipes to provide for expansion due to a rise in temperature. In all, nine full-scale pipe bends were tested in the laboratories of the Massachusetts Institute of Technology, varying in diameter from 4½ inches to 14 inches, and with a radius of curvature from one and one half to six times the diameter. The thickness of the pipe wall covered a wide range, the pipes being designed for steam pressures varying from about 100 to 600 pounds per square inch. The analysis of the tests led to the following general conclusions: (1) The calculated values of the displacement of the ends of a bend relative to each other, as also of the sectional deformations, showed an excellent correspondence with the observed values. The calculated stresses, longitudinal as well as transverse, corresponded well with the stresses obtained by measurements so long as the material was within the elastic limit. (2) The elastic yielding capacity of the pipe bends seemed to be dominated by the magnitude of the longitudinal stresses. It was found that so long as these stresses did not exceed 20,000 pounds per square inch, there was no appreciable permanent set in a bend, although probably local overstrain existed at certain points. On the basis of these results it was recommended to design pipe bends for a calculated longitudinal stress of 16,000 pounds per square inch. A special study was made of the occurrence of plastic flow in the material, evidenced chiefly by the appearance of Lüders lines on the surface of the pipes, and indicated also by the measurements of the strain meters. The principal formulas used in the analysis are given in an appendix.

The effect of the annihilation of matter on the wave-length of light from the nebulae: Richard C. Tolman. The purpose of this paper is to examine the cause of the red-shift in the light from the extra-galactic nebulae, which has been found by Hubble and Humason to increase approximately linearly with the distance of the nebulae, and if interpreted as an ordinary Doppler effect would correspond to enormous velocities of recession for the more distant objects of this class. The method of attack is to investigate, on the basis of the principles of general relativity, what form of line element for the universe as a whole would correspond to the continuous transformation of matter into radiation which appears to be going on throughout the universe and then determine if this form of line element would have any effect on the wave-length of light from distant objects. Attention is first called to the fact that neither of the rival static line elements for the universe proposed by Einstein and by de Sitter gives a satisfactory explanation of the red-shift, and that previous work of the author has shown that these are the only *static* line elements which would agree with approximately uniform conditions throughout the universe. These static line elements, however, correspond in the Einstein case to a universe permanently filled with a constant distribution of matter and in the de Sitter case to a universe which is permanently empty. Hence if we accept the contemporary opinion of the astro-physicists that the universe is actually filled with a distribution of matter, which is continuously changing over into radiation, we must expect that the actual line element for the universe will be a non-static one corresponding to the non-static condition of the universe. By applying the requirements that conditions throughout the universe shall on the average be substantially uniform, and that particles (nebulae) which are at rest in the coordinates chosen shall remain so, as is necessary for the preservation of a stable distribution, the author is then able to obtain for the line element of the universe the expression

$$ds^2 = -\frac{e^{g(t)}}{\left(1+\frac{r^2}{4R^2}\right)^2}(dx^2+dy^2+dz^2)+dt^2 \qquad (1)$$

where R is a constant and g is a function of t which gives the dependence of the line element on the time. With the help of this form of line element, it is then possible to obtain an expression for the density of matter in the universe and to show that g must be changing with the time if a general transformation of matter into radiation is really taking place. Furthermore, if we apply the additional requirement that particles (nebulae) which are not exactly stationary in the coordinates chosen tend to become so, it can be shown that g must be increasing with the time, and this leads to a red-shift in the light from distant objects. Finally, assuming in the neighborhood of $t=0$ a simple linear dependence on time,

$$g = a + 2kt \qquad (2)$$

it is found that k is a quantity which is related on the one hand to the average rate at which matter is changing over into radiation and on the other hand to the known shift in wave-length with distance. By comparison with observational data it is then shown that the value of k necessary to account for the known red-shift falls close to the range of values which would correspond to the rates of transformation of matter into radiation for actual stars of different types, although considerably higher than that for an average star. In conclusion, it is pointed out that further information as to the exact dependence of the red-shift on distance and knowledge as to the concentration of dust in the universe and its rate of annihilation are very desirable. It is also emphasized that the simplification of the model used for the calculation and the assumptions, such as that of a linear dependence on time, make it necessary to regard the treatment given as not better than a first approximation to the correct theory.

The energy requirements of intense mental effort: FRANCIS G. BENEDICT and CORNELIA GOLAY BENEDICT. The popular tradition that fish is a brain food has given way to the idea that mental effort demands calories. The feeling of complete mental and physical exhaustion as an aftermath of intense, sustained mental effort has led to interest in the real dynamic effect of so-called "mental work." By measuring the changes in the heart rate, the respiration rate, the character of the respiration, the carbonic acid exhalation and especially the consumption of oxygen, definite evidence can be secured of the immediate results of intense mental effort. Studies made in earlier years on the influence of mental work upon heat production have shown either that the mental effort had no effect or a very pronounced effect. Further experiments have been made during the winter of 1930 at the Nutrition Laboratory of the Carnegie Institution of Washington, at Boston, in which the subjects (five men and one woman) were measured under three different conditions: first, during complete muscular and digestive repose and as nearly as possible in a state of mental vacuity; second, during "attention" or response to an electric signal, but with no active cerebral processes of a complex nature; third, during intense, sustained mental activity, as in the elaboration of mental arithmetic problems for an hour, at the end of which time each subject admitted that he was exhausted, at least mentally. The first series of observations with each subject represented the measurement of the now well-known "basal metabolism," a measurement made daily in the hospital, especially in suspected thyroid cases, and likewise used as evidence of the level of vital activity of normal persons. The problems, such as multiplying mentally 73 by 47, were given orally, and at the completion of each problem the subject touched a telegraph key. Problem followed problem as rapidly as solved, and with one subject a complexity represented by numbers such as 873 by 67 was reached successfully. The general picture of the effect of mental effort was the same with all subjects, a distinct increase in heart rate, a pronounced alteration in the general character of the respiration, a small increase in the carbonic acid exhalation and a slightly smaller increase in the oxygen consumption. In the periods of repose following the mental work all these factors immediately resumed their former level and nature. During the mental effort, lasting in some cases more than an hour, the different factors measured showed no increase from period to period during the four consecutive fifteen-minute periods. The response to mental effort is therefore immediate and not cumulative, at least when the mental effort is uniform in nature. From the slight increase in the carbonic acid exhalation and the oxygen consumption it is possible to calculate the extra heat produced during such mental effort, that is, the increase above the heat production during complete muscular, digestive and mental repose. From the standpoint of dynamics it is perhaps surprising that the extra caloric demands of mental effort are so small. The professor absorbed in intense mental effort for one hour has an extra demand for food or for calories during the entire hour not greater than the extra needs of the maid who dusts off his desk for five minutes. The cloistered scholar at his books may be surprised to learn that the extra calories needed for one hour of intense mental effort would be completely met by the eating of one oyster cracker or one half of a salted peanut.

The suppression of fluorescence in concentrated solutions: ERNEST MERRITT. In dilute solutions the "specific fluorescence" of a substance, *i.e.*, the fluorescent emission per molecule, has been found to be constant throughout a considerable range. But as the concentration is increased a point is finally reached at which the specific fluorescence suddenly begins to diminish exponentially with increasing concentration. Apparently when the molecules of the active substance are sufficiently close together some action occurs which inhibits the process of emission. It has been suggested that we have to do with collisions of the second kind or with some inductive action between the molecules which disturbs the conditions for radiation. Assuming that some action of this kind occurs when the distance between molecules is less than some specified distance, and assuming further that the active molecules are distributed at random, a law of variation of fluorescence with concentration has been derived for liquids by Perrin and for solids by Merritt. But this law indicates an exponential variation for *all* values of the concentration. In some cases the experimental results reported by Wawilow differ by as much as 50 per cent. from those computed by Perrin's formula. Abandoning the idea of random distribution the author assumes that the potential energy of the molecule of active material when at a distance from other similar molecules is less than its energy when near another active molecule. This makes it necessary to introduce the Boltzmann distribution law in computing the probable distribution and leads to a new expression for the specific fluorescence, F, namely:

$$F = \frac{F_o}{1 + (e^{\mu n} - 1)e^{Q/kT}}.$$

n = concentration; Q = energy (negative) required in bringing two active molecules together from a great distance; μ = a constant determined by the maximum distance apart at which one active molecule prevents radiation by the other. This expression represents the experimental results better than that derived on the assumption of random distribution. For large values of n the expression takes the form

$$F = F_0 \, e^{-\mu(n-n_0)},$$

which was given by Wawilow as best representing his results. The corresponding expression for the observed fluorescence in the case of a solid is also derived and is found to agree with the experimental results. The complicating effects of dissociation and the possible causes of the inhibiting action are discussed.

X-ray diffraction determinations of electron distributions in atoms: ARTHUR H. COMPTON. Work by Darwin, the author, the Braggs, Duane and others has made it possible to estimate from measurements of the intensity of X-ray diffraction by crystals the distribution of the electrons in the atoms of which the crystals are composed. Similar analysis now shows that the density of distribution of the electrons as a function of the distance from the center of an atom may be expressed as a Fourier integral, which can be evaluated from the observed intensities of the X-rays diffracted by amorphous substances. The theory, which is based on classical electrodynamics, is identical with the results of the quantum mechanics, except for a small correction which is to be applied when dealing with the diffraction of short waves at large angles. A comparison of the results obtained from the diffraction by gases with those calculated from the diffraction by crystals shows a close agreement in the general form of the electron distribution curves. The data from the gases show, however, a stronger concentration of the electrons near the center of the atom, a result which is doubtless due to the thermal agitation of the atoms in the crystal lattice, which gives to these atoms an apparent diffuseness. In fact, we are thus afforded an interference method of determining the amplitude of the atomic motions in a crystal lattice. The results are in qualitative accord with those to be expected from the usual kinetic theory.

Absorption spectra and the problem of the pyrones: R. C. GIBBS, J. R. JOHNSON and E. C. HUGHES (introduced by Ernest Merritt). Organic compounds that contain a pyrone ring exhibit certain unusual properties. Strictly chemical evidence as well as that of absorption spectra has led to conflicting suggestions regarding the structural formulas for the pyrones and their acid salts. Arguments have been advanced for the free substance chiefly in favor of either the ketonic structure with a quinoid-like nucleus or an inner salt formula, the nucleus of which is benzenoid. In forming an acid salt, the acid radical has been considered to be attached to either of the two oxygen atoms or to the carbon atom involved in the ketonic linkage thus producing either an oxonium or a carbonium salt. In seeking to secure crucial data that might serve to clarify the problem, the absorption spectra of gamma-pyrone, dimethyl pyrone, benzopyrone and xanthone in absolute alcohol and alcoholic HCl were carefully examined. Sulphuric acid solutions of two of these compounds were also examined. Whenever dissociation might conceivably occur and thus possibly modify the results, ether or dimethyl sulphate solutions were also measured. The absorption for the neutral solutions of gamma-pyrone and dimethyl pyrone is characteristic of that found for compounds known to have a ketonic linkage which, in these cases, involves a quinoid-like nucleus. Although the absorption in the case of neutral benzopyrone and xanthone is more complex due to the presence of benzene rings, the ketonic type of absorption also appears to be present in these compounds. The absorption curve for the acid solution of each of these four compounds resembles that for the corresponding neutral solution. It is therefore concluded that in forming an acid salt of these pyrones, the ketonic linkage is not broken and that an oxonium salt is produced through addition to the ketonic oxygen atom. The formation of a carbonium salt would have necessitated a rupturing of the ketonic linkage, thus producing a marked change in the nature of the absorption spectra. Furthermore the resemblance between the absorption of the free pyrones and that of their acid salts gives fairly conclusive evidence that these salts do not have an oxonium benzenoid structure, for such a structure would have yielded widely modified absorption spectra. Additional confirmation of these conclusions is obtained by comparing the absorption of 4-methoxy lutidine, a compound in which only the benzenoid structure is possible, with that of its ketonic isomer, N-methyl lutidone. The absorption spectrum of lutidone bears a close resemblance to that of pyrone, but that of lutidine is radically different, being similar in character to those for benzene and toluene.

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